CLAIMS

We claim:

1. A composite membrane comprising:
a porous support; and a lyotropic liquid crystal (LLC) polymer porous membrane attached to the support, the LLC membrane having a thickness less than about 1 micron and a pore structure having hexagonally ordered, cylindrical nanopores.

2. The composite membrane of claim 1, wherein the pore size of the support is less than about 0.1 micron.

3. The composite membrane of claim 1, wherein the thickness of the LLC membrane is less than about 0.5 microns.

4. The composite membrane of claim 1, wherein the LLC membrane is a single layer.

5. The composite membrane of claim 1, wherein the porous support is selected from the group consisting of polyacrylonitrile (PAN), polyacrylonitrile-*co*-polyacrylate, polyacrylonitrile-*co*-methylacrylate, polysulfone (PSf), Nylon 6, 6, poly(vinylidene difluoride), and polycarbonate supports.

6. The composite membrane of claim 1 wherein the composite membrane has a flux of at least 0.2 kg/(m^2 hr) with a pressure differential of 60 psi (0.4137 MPa).

7. The composite membrane of claim 1 wherein the pores of said LLC polymer membrane incorporate a chemical complexing agent.

8. A composite membrane comprising:
a porous support; and
a lyotropic liquid crystal (LLC) polymer porous membrane attached to the support, the LLC membrane having a thickness less than about 10 microns and a pore structure of interconnected, ordered, 3-D nanopores.

9. The composite membrane of claim 8 wherein the pore size of the support is less than about 0.1 micron.

10. The membrane of claim 8, wherein the porous support is selected from the group consisting of polyacrylonitrile (PAN), polyacrylonitrile-*co*-polyacrylate, polyacrylonitrile-*co*-methylacrylate, polysulfone (PSf), Nylon 6, 6, poly(vinylidene difluoride), and polycarbonate supports.

11. The membrane of claim 8, wherein the pores of said LLC polymer membrane incorporate a chemical complexing agent.

12. A method for making a composite nanofiltration membrane comprising an ultraporous support and a LLC polymer porous membrane attached to the support, the method comprising the steps of:
providing the ultraporous support;
preparing a solution comprising a LLC monomer, an organic solvent for the monomer, a polymerization initiator and water, wherein the organic solvent is selected to be compatible with the support;
applying a layer of the solution onto the support;
evaporating the solvent from the solution; and
cross-linking the LLC monomer.

13. The method of claim 12 wherein the solution is applied to the support by roller casting.

14. The method of claim 12 wherein the pore size of the support is less than about 0.1 micron.

15. The method of claim 12 wherein the LLC monomer is selected from the group consisting of inverted hexagonal (H_{II}) forming monomers and bicontinuous cubic (Q) forming monomers.

16. The method of claim 12 wherein the LLC monomer forms the inverted hexagonal phase.

17. The method of claim 16 wherein the LLC polymer membrane thickness is less than about 1 micron.

18. The method of claim 16 wherein the LLC polymer membrane thickness is less than about 0.5 microns.

19. The method of claim 12 wherein the LLC monomer forms the bicontinuous cubic phase.

20. The method of claim 19 wherein the LLC polymer membrane thickness is less than about 10 microns.

21. The membrane of claim 12, wherein the porous support is selected from the group consisting of polyacrylonitrile (PAN), polyacrylonitrile-*co*-polyacrylate, polyacrylonitrile-*co*-methylacrylate, polysulfone (PSf), Nylon 6, 6, poly(vinylidene difluoride), and polycarbonate supports.

22. A method for making a composite nanofiltration membrane comprising a porous support and a LLC polymer porous membrane attached to the support, the method comprising the steps of:
providing the porous support;
preparing a solution comprising a LLC monomer, an organic solvent for the monomer, a polymerization initiator, and water, wherein the monomer forms the inverted hexagonal phase and the organic solvent is selected to be compatible with the support;
applying a layer of the solution onto the support;
evaporating the solvent from the solution; and
cross-linking the LLC monomer, whereby the thickness of the LLC polymer porous membrane is less than about 1 micron.

23. A method for making a composite nanofiltration membrane comprising a support and a LLC polymer porous membrane attached to the support , the method comprising the steps of:
providing a porous support;

preparing a solution comprising a LLC monomer, an organic solvent for the monomer, a polymerization initiator, and water, wherein the monomer forms the bicontinuous cubic phase and the organic solvent is selected to be compatible with the support;
applying a layer of the solution onto the support;
evaporating the solvent from the solution; and
cross-linking the LLC monomer, whereby the thickness of the LLC polymer porous membrane is less than about 10 microns.

24. A process for separating a component of a first fluid mixture, comprising the steps of:
bringing said first fluid mixture into contact with the inlet side of a separation membrane, said separation membrane comprising a LLC polymer porous membrane attached to a ultraporous support membrane,
applying a pressure difference across said separation membrane; and
withdrawing from the outlet side of said separation membrane a second fluid mixture, wherein the proportion of said component is depleted, compared with said first fluid mixture.

25. The process of claim 24, wherein the pores of said LLC polymer membrane are smaller than the molecular size of said component.

26. The process of claim 24, wherein the pores of said LLC polymer membrane incorporate a chemical complexing agent.